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GEODESY.—*The scientific and practical value of triangulation.*[1] WILLIAM BOWIE, U. S. Coast and Geodetic Survey.

Triangulation, as is well known, is a method of surveying by means of which the distances and directions between widely separated points on the earth's surface can be determined with almost any degree of accuracy desired. When the triangulation is connected with astronomical determinations of latitude, longitude and azimuth, geographic positions of points on the earth's surface can be derived.

Triangulation is based on the elementary mathematical principle that when the length of one side of a triangle and the angles of that triangle are known the lengths of the other two sides can be computed. In actual practice base lines, varying in length from 4 to 15 miles, are measured on suitable terrain and from such bases chains of triangles are extended across the country to cover areas that are to be investigated scientifically or which are to be surveyed and mapped. Necessarily, the two ends of a triangle side must be intervisible from the ground, or structures in the form of stands or towers must be erected in order that the observer at one end of the line may see a pole, target, heliotrope or lamp placed directly over the station at the other end.

Every nation of the world that is well-developed industrially has at least made a start in extending a triangulation net over its area. In the United States we have about 27,000 miles of arc of first-order triangulation and traverse, by which geographic positions are determined, in addition to what is called third-order triangulation which has been executed along our coasts. Then, in the interior of the country, there is a large amount of triangulation of various orders below first-order which has been used in the topographic mapping.

[1] Received January 11, 1930.

FIRST-ORDER TRIANGULATION OF NORTH AMERICA.
Black bands in Canada indicate work completed or for which reconnaissance has been done.
Black bands in Mexico and the United States indicate work accomplished.
Hatched bands in Canada and the United States indicate work contemplated for the immediate future.
Very narrow bands indicate traverse.
January 1, 1930.

**Fig. 1.—Triangulation of North America, showing recent work in Canada, the United States, and Mexico.**

First-order triangulation which is the framework on which all lower orders are based is now being executed only by the Coast and Geodetic Survey. This bureau will supplement the first-order work with arcs of second-order triangulation. The arcs of these two classes of triangulation will be so spaced that when the network is completed there will be few places in the United States more than about 25 miles from a first or second-order triangulation station.

In this high grade triangulation the best available theodolites are used. The tendency has been during the past few decades to reduce the theodolites in size but to increase the accuracy with which the parts are fitted together, to improve the optics and to increase the refinement with which the horizontal circle is graduated or divided. Since the atmosphere is seldom very clear, only in exceptional cases is it possible to make observations on poles or targets, for the lines are in general more than 8 miles long and sometimes reach a length of 100 miles or more. Heliotropes have been used as targets on which to make observations but they can only be employed when the sun is shining and even then only during the latter part of the afternoon when the atmosphere becomes steady. For several decades the Coast and Geodetic Survey has been making practically all the angle measurements for the main scheme of triangles at night. For this purpose, automobile headlights, each provided with a contracted filament lamp, are used. The beam going out from such a lamp can be easily observed with the unaided eye at distances varying up to 40 miles if the atmosphere is at all favorable. In some parts of the country, notably the southwest where the atmosphere is generally quite clear, the light from the signal lamp has been seen with the unaided eye over distances of more than 100 miles.

Thirty-two pointings are made over each line of the triangulation during the angle measurements and the average of the results is used as the direction to be employed in computing the angles of the triangles. Necessarily in the computations the spheroidal shape of the earth's surface must be taken into consideration. If the lines are only a fraction of a mile long the curvature of the earth really does not affect the measured angles, but the spherical excess, the amount that the sum of three angles of a spherical triangle exceeds 180 degrees, is in some cases more than one minute.

The closing error of the triangles as observed for first-order triangulation averages slightly under 1″. This accuracy is all that is required for any except the most special scientific work.

The base lines of the triangulation are measured now with 50-meter invar tapes and the probable error of the derived length is seldom greater than one part in a million. The actual error is believed to be seldom or never greater than 1/300,000.

The principal purposes of the triangulation are eminently practical. In the subdivision of our country into states, counties and even smaller political units, it is essential that the boundary lines be known in their proper geographical positions. The triangulation of the country furnishes just the information that is needed in the accurate location of such political boundary lines. It is also essential that the boundaries of private property be easily recoverable. This can be assured whenever geographic positions or plane coordinates are determined for the angle points of the boundary of a farm or of a city lot. When such coordinates have been given and they are referred to the general triangulation system of the country, it is possible to relocate the boundary corners even though all of the monuments set on them may have been destroyed.

Triangulation furnishes information of value in connection with the alignment surveys of highways and railroads and in bridge and tunnel location and construction. Also it furnishes the basis for the surveys made along rivers for flood control or river improvement. Its most important practical value is in connection with the charting of the coasts and the topographic mapping of the country. Commercial and naval vessels must have accurate charts. There are few important human activities that do not depend for their successful execution on exact knowledge of geographic positions, distances, directions, elevations and the configuration of the ground. All of this information is furnished by the modern topographic map. That map in turn depends on the triangulation system of the country in order that the various adjoining sections of it may be accurately fitted together. When the triangulation system of the whole country is used in mapping there will not be those gaps, overlaps and offsets where two maps meet which often bother the cartographer who constructs them and others who use them. Triangulation is used extensively in military surveying and mapping.

Triangulation also has very important scientific values. It is only by means of connected arcs of triangulation with the astronomic latitudes and longitudes determined at some of the stations that one can determine the dimensions of the earth. From gravity data alone the shape of the earth can be obtained, but triangulation by which dis-

tances across wide areas are measured is necessary for the determination of the size. The shape and size of the earth have already been determined a number of times but in each case the data used covered only a comparatively small part of the earth's surface. With more extensive data over greater areas closer approximations to the true figure of the earth can be made.

The shape and size of the earth are needed in all surveying and mapping operations which are executed on a large scale, in navigation, and in explorations. The figure of the earth is needed as well as the distances between widely separated points in connection with certain astronomical observations, especially in the determination of the parallax of the moon.

It has been found that the combination of astronomical and triangulation data enable one to learn much in regard to deviations from normal density in the outer portion of the earth. In fact it is by means of astronomical and triangulation data that the first comprehensive quantitative test of isostasy was made. It was found that the material under continental areas is lighter than normal while the material under ocean areas is heavier than normal. The deviations from normal density were found to be sufficient to balance the topographic features. This condition of balance or equilibrium of prisms of the earth's crust is called isostasy.

While the application of the principle of isostasy to triangulation and astronomical data brought these data into very close agreement it was found that there were some outstanding differences. Further investigation in the field of isostasy involving values of gravity led to the rather definite conclusion that the abnormalities or residuals in the geodetic data resulted from the presence of extra heavy or extra light material near the geodetic stations, both horizontally and vertically. It seems to be reasonably certain that the deflections of the vertical, as differences between triangulation and astronomical data are called, can be used for the purpose of disclosing buried structure. There is now available in the United States a large amount of geodetic data in the form of deflections of the vertical which can be used in connection with geological studies.

Now that isostasy has been substantiated as a scientific principle we are able to use triangulation and astronomical data to show the deviations of the geoid or water surface of the earth from the spheroid or mathematical surface which most nearly fits the geoid. A surface can be passed through the astronomical stations at right angles to the direc-

tion of gravity and also through the derived directions of gravity at places where triangulation has not been executed or astronomical observations made, but where the deflection of the vertical on the isostatic principle has been computed. What might be called a geoid contour map could be constructed which would show the deviations of the geoid from the spheroid.

One of the most notable cases of the use of triangulation in a scientific problem was the measurement, by means of a base and triangulation, of the distance between San Antonio Peak and Mt. Wilson in southern California for the use of Prof. A. A. Michelson in the determination of the velocity of light. The length of the base was about 22 miles while the distance between the two peaks was about 23 miles. Every possible correction was applied to the triangulation in order to eliminate the effect of systematic errors. The base line was measured with a probable error of about one part in 10 million, while the probable error of the distance between the two peaks was about one part in 6 million. It seems reasonably certain that the distance furnished Prof. Michelson was not in error by as much as one millionth of the distance.

Triangulation has been used in this and other countries in the determination of the distortion of the earth's surface during earthquakes. Already rather extensive investigations have been made in California by means of triangulation, and plans are now being formulated for an extension of the tests. Arcs of triangulation are being extended across areas where there are fault zones which have been active in historical or at least in late geological time. It is planned to have this triangulation repeated at intervals of ten or some other number of years to see if any strains have taken place in the earth's material. Should an earthquake occur along any of the faults or in fact anywhere in the vicinity of this triangulation the work will be repeated in order to learn how much movement of the ground had occurred at different distances from the fault, and how far from the fault one must go in order to find undisturbed points. These tests by triangulation in regions of seismic activity are of particular importance to the geologist for by them he can obtain an idea as to whether an earthquake is a local or a general phenomenon.

The Coast and Geodetic Survey has in the last few years made a readjustment of the triangulation net of the western half of the United States involving about 13,000 miles of arc. The bureau is now engaged in the computation and adjustment of the net of the eastern half of the country. The latter work will be completed in the next two or three

years after which standard or final geographic positions can be furnished for the triangulation stations to engineers, scientific workers, or others who may need the data. Of course there is no such thing as a final position for there is abundant evidence that the earth's surface during geological time has undergone changes both vertical and horizontal, but it seems reasonably certain that very few of the triangulation stations of this country will be affected by geological processes to an extent that will vitiate the data in a few hundred years at least. Regions of considerable seismic activity will of course have triangulation stations whose positions are likely to change during earthquakes and even between such earthquakes but such areas form only a small portion of the total area of the country.

The accuracy of the triangulation, as shown by the adjustment of the western net, is quite remarkable. There were 16 circuits with perimeters averaging about 1200 miles. The average closing error of these circuits was about one part in 430,000. There were only two of the circuits for which the closing error was greater than about 1/200,000. While it is doubtful if the length of a line of triangulation is known with an accuracy greater than 1/100,000, yet where there is a series of such lines combined to measure a distance across country, the errors of the individual lines tend to balance out according to the law of accumulation of accidental errors.

The scientific and practical needs for triangulation data are increasing from year to year. The demands for such data have led the President of the United States to include in his budget for the fiscal year 1931 a substantial increase in the money to be devoted to geodetic surveys, including triangulation. It is hoped that the triangulation net composed of first and second order work will be finished within the next ten or twelve years.

## PALEONTOLOGY.—*A Cretaceous pelecypod with color markings.*[1]

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Color markings are so rarely preserved on fossil shells that the exceptional case of their preservation seems always worthy of record, particularly where the genus concerned is extinct. The writer here presents a note and figures descriptive of a species of *Inoceramus* related to *Inoceramus stantoni* Sokolow from the lower part of the Mancos

[1] Received January 4, 1930. Published with the permission of the Director of the U. S. Geological Survey.

shale of Vermilion Creek, Moffat County, Colorado.[2] The specimens are completely flattened in a calcareous shale and the original sculpture and outline may be only guessed at. The fossils in adjacent layers, however, show that the age of the beds is that of the lower part of the Niobrara limestone (Coniacian).

The markings on these shells show as light-brown, nearly straight bands radiating from the beaks and gradually increasing in width toward the basal margins. The width of the individual bands differs much, though there seems to be a wider band near the middle of each shell and narrower bands on each side of it. What the original color of the bands may have been seems scarcely worth conjecture, but it is beyond doubt that the pattern preserved is that of the coloring of the shell in life.

Figure 1.—*Inoceramus* aff. *I. stantoni* Sokolow, from the Mancos shale of Vermilion Creek, Colorado. Three individuals showing color markings. U. S. National Museum cat. No. 73736.

PETROGRAPHY.—*Pacificite, an anemousite basalt.*[1] TOM. F. W. BARTH, Geophysical Laboratory, Carnegie Institution of Washington. (Communicated by L. H. ADAMS.)

*Introduction.* In many lavas the amount of silica is insufficient for the formation of feldspar, and consequently minerals undersaturated in silica are formed, among them the feldspathoids. Microscopic investigations of the undersaturated lavas of the Pacific island volcanoes have shown that nephelite occurs throughout the area, forming

[2] See THIS JOURNAL, 20: 40. 1930.

[1] Received January 18, 1930.

nephelite basanite, as well as phonolitic trachyte and, rarely, phonolite, these lavas being in much smaller amount than the basalts. The minerals of the sodalite group and analcite, as well as melilite, occasionally occur, but the feldspathoid leucite is never met with at the Intra-Pacific volcanoes.

It has been noted, however, that there occur certain purely feldspathic basalts, without nephelite and usually with olivine, the analyses of which show the presence of very considerable amounts of nephelite in the norm, although none of this appears in the rock. A number of these rocks have been studied by me and the conclusion has been arrived at that much of what is apparently a normal plagioclase is in reality anemousite.

Anemousite is a plagioclase with carnegieite in solid solution, carnegieite being the triclinic form of the molecule $Na_2Al_2Si_2O_8$, which ordinarily occurs as the hexagonal nephelite. Anemousite was first described by Washington and Wright[2] on specimens from the island of Linosa, in the Mediterranean, this being, so far, the only known occurrence. Carnegieite has been made artificially,[3] and it appears to be the abnormal nephelite described by Esch from the Kamerun.[4] Bowen[5] has studied the system, nephelite (carnegieite)-anorthite. The possibility of the presence of anemousite or carnegieite instead of nephelite in lavas, dependent on the conditions of solidification, was pointed out in the paper on the feldspar from Linosa, in which it is said (p. 64): "With identical chemical composition of the rock, we would have in the one case a nephelite tephrite, and in the other a feldspar basalt, but the norms of both would be the same and would show normative nephelite." The pacificites are an example of this.

We have in these lavas a rock that, under other conditions, would have contained very considerable nephelite, whereas this molecule actually enters a triclinic plagioclase. Under the former conditions the rock would be a nephelite basanite or tephrite, while it has the mineral composition of a feldspar basalt. Recognition of this difference seems to be called for, so that I propose the name *pacificite* for this group of anemousite basalts. If olivine is present in abundance the rock would be called olivine pacificite. This name is appropriate inasmuch

[2] WASHINGTON and WRIGHT, Am. Journ. Sci. **29**: 52–70. 1910.

[3] THUGUTT, Neues. Jahrb., Beil. Band **9**: 561. 1894; WASHINGTON and WRIGHT, op. cit., p. 64; BOWEN, Am. Journ. Sci. **33**: 564. 1912; BOWEN and GREIG, Ibid., **10**: 204. 1925.

[4] E. ESCH, Sitzb. Berl. Akad. **18**: 400. 1901.

[5] BOWEN, op. cit., pp. 551–573.

as such anemousite-bearing lavas would seem to be widely scattered throughout the Intra-Pacific basin, as is shown by the descriptions and analyses published by Lacroix, Washington, and others. For example, in discussing the lavas of Maui, it is remarked[6] that the alkalic tendency of these rocks is indicated "by the constant presence, *modal or normative or both*, of nephelite in the andesites and basalts of Haleakala."

Although the feldspar of the pacificite is undersaturated it can not be called feldspathoid, and consequently the rock can not be reckoned with the tephrites or basanites, because according to the definition of these the presence of a feldspathoid is essential. Therefore pacificite is to be classed with the basalts.

*Mineral composition.* A quantitative description of two pacificites follows.

1. *Pacificite.* Three miles from Rest House, Haleakala, Maui, Hawaiian Islands. Analyzed by M. G. Keyes, under name of nephelite andesine basalt.[7]

This rock is somewhat trachytoidal in texture. Abundant thin laths of plagioclase grade on the one hand into larger phenocrysts (labradorite), and on the other hand into an interstitial groundmass (anemousite). Very few phenocrysts of euhedral olivine, and many of grayish brown pyroxene are present. In the groundmass very minute augite grains and much ore are met with.

*Olivine* (2 per cent[8]). The axial angle is very close to 90°, some grains probably show a negative character. The composition is consequently about 15 fayalite.[9]

*Pyroxene.* The phenocrysts and microphenocrysts of pyroxene make up 15 per cent of the rock; the amount in the groundmass is probably somewhat lower. The axial angle is $2V\gamma = 56° \pm 3°$, dispersion $\rho > v$, the extinction angle is $c : \gamma = 48°$. The refringence shows some variation, indicating a different composition of the various grains; an average value is $\beta = 1.705$.

The value of 2V indicates that no appreciable amount of either clinoenstatite or acmite can be present, and the value of $\beta$ indicates an amount of about 50 per cent of the diopside molecule, the rest being chiefly hedenbergite.

[6] WASHINGTON and KEYES, Am. Journ. Sci. 15: 216. 1928.

[7] WASHINGTON and KEYES, op. cit., p. 210.

[8] This is the volumetric percentage found by the Rosiwal method.

[9] This is approximately the composition of the olivine of Kilauea, as shown by AUROUSSEAU and MERWIN (Am. Mineral. 13: 560, 1928).

*Ore* (8 per cent). The percentage of ore shown in the thin sections is less than that shown in the norm. This is because much of the normative magnetite and ilmenite is modally present in the augite. It was not possible to determine the relative amounts of magnetite and ilmenite in the thin sections, but the norm indicates that the amount of ilmenite is equal to that of the magnetite or that the latter is very titaniferous.

*Feldspars.* The phenocrysts show the following properties:

The lowest index of refraction, $\alpha = 1.557$ : 55 An
Maximum extinction in zone $\perp$ (010), $\alpha' : (010) = 33°$ : 58 An
Positive axial angle, $2V = 75°$ : 55 An
Extinction angle in section $\perp\gamma$, $a : \alpha = 28°$ : 53 An.

This feldspar may be an anemousite, for the data correspond fairly well with those given by Wright[2] for the anemousite from Linosa. However, the above data also fit in very well with a normal labradorite, and since no further proofs of the presence of carnegieite are obtainable, the feldspar of the phenocrysts may be regarded as a normal plagioclase of about 50 An.

TABLE 1.—CALCULATION OF THE MINERAL COMPOSITION OF PACIFICITE FROM HALEAKALA

| | Ore | Anemousite Labradorite | | | | Oliv. (15 Fa) | Pyrox. | Apat. | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | Or | Cg | Ab | An | | | | |
| $SiO_2$ | | 6.9 | 6.7 | 14.5 | 4.6 | 0.8 | 12.1 | | 45.6 |
| $TiO_2$ | 4.3 | | | | | | 0.8 | | 5.1 |
| $Al_2O_3$ | | 1.9 | 5.7 | 4.1 | 3.9 | | 0.6 | | 16.2 |
| $Fe_2O_3$ | 3.5 | | | | | | 0.9 | | 4.4 |
| FeO | 5.5 | | | | | 0.3 | 1.9 | | 7.7 |
| MgO | | | | | | 1.0 | 3.1 | | 4.1 |
| CaO | | | | | 2.1 | | 5.7 | 0.7 | 8.5 |
| $Na_2O$ | | | 3.5 | 2.5 | | | 0.1 | | 6.1 |
| $K_2O$ | | 1.8 | | | | | | | 1.8 |
| $P_2O_5$ | | | | | | | | 0.5 | 0.5 |
| Total | 13.3 | 10.6 | 15.9 | 21.1 | 10.6 | 2.1 | 25.2 | 1.2 | 100.0 |

The more sodic feldspars of the groundmass, however, certainly exhibit optical properties that do not correspond with those of any normal feldspar series.[10] The shading of the feldspar laths into an interstitial groundmass is accompanied by a lowering of the refringence. A common value of the mean index is $\beta = 1.550 \pm$, while $\alpha$ still is higher

[10] This was referred to andesine or oligoclase-andesine by WASHINGTON and KEYES, who determined the optical characters only approximately.

than 1.545; the axial angle of such grains is (+) 2V = 60° ± 3°. It is hardly possible to detect any grains with $\beta$ lower than 1.550, obviously indicating that neither nephelite nor ordinary alkali feldspars are present.

There does not exist any known mineral with the above stated optical properties. But since the aspect is very much like that of a feldspar, and since the chemical analysis of the rock shows that some undersaturated mineral has to occur, a plausible explanation is that this mineral belongs to the anemousite series.

The calculation of the rock analysis is shown in Table 1. Table 2 shows the mode compared with the norm.

TABLE 2.—MODE AND NORM OF PACIFICITE FROM HALEAKALA

| Mode | | Norm | |
|---|---|---|---|
| Anemousite | 48 | Or | 10.6 |
| Plagioclase (50 An) | 10 | Ab | 21.0 |
| | | An | 11.7 |
| Pyroxene | 25 | Ne | 16.5 |
| Olivine (15 Fa) | 2 | Di | 21.5 |
| | | Ol | 1.3 |
| Ore | 13 | Mt | 6.5 |
| | | Il | 9.7 |
| Apatite | 1 | Ap | 1.3 |

A pyroxene from Haleakala has already been studied by Washington and Merwin.[11] A comparison of the composition of this pyroxene[12] with the calculated composition of the pyroxene in the pacificite gives a further proof of the correctness of the interpretation of the rock analysis. The molecular compositions (by weight, with titanium dioxide reckoned with silica) are as follows.

| | Analyzed augite | Augite from pacificite |
|---|---|---|
| Diopside | 69 | 66 |
| Hedenbergite | 15 | 25 |
| Acmite | 5 | 3 |
| Enstatite | 2 | – |
| Sesquioxides | 9 | 5 |

For the analyzed augite: $\beta$ = 1.706, c:$\gamma$ = 48°, 2V = 60°; for the pacificite augite: $\beta$ = 1.705, c:$\gamma$ = 48°, 2V = 56°.

[11] WASHINGTON and MERWIN, Am. Journ. Sci. 3: 117. 1922.

[12] This pyroxene was found along the trail from the Rest House to Red Hill.

The slightly higher content of hedenbergite in the augite of the pacificite is probably due to the admixture of the groundmass pyroxenes which presumably are richer than the phenocrysts in iron.

The anemousite is not homogeneous but consists of a series of solid solutions. The average composition by weight calculated from the chemical analysis comes out as follows:

| | |
|---|---|
| Orthoclase | 22 |
| Albite | 33 |
| Anorthite | 12 |
| Carnegieite | 33 |

This composition must correspond with fair accuracy to that of the average feldspar of the groundmass of the rock. No serious alteration of the figures is possible, and since the optical properties of the groundmass exclude with certainty any ordinary undersaturated mineral, the fact that this rock represents a new lava type has been established, and in all probability the undersaturated mineral must be looked upon as an anemousite feldspar.

2. *Olivine pacificite.* Kaula Gulch, above Ookala, Mauna Kea, Hawaii, Hawaiian Islands. Analyzed by H. S. Washington and by him called chrysophyric basalt.[13]

This lava contains abundant phenocrysts of olivine in a very fine grained, grayish groundmass consisting of small crystals of pyroxene, a little ore and some feldspar laths that partly grade into an interstitial feldspar-like mineral.

*Olivine* (17 per cent). The negative axial angle is 85°, the mean index of refraction, $\beta = 1.703$, corresponding to 26 Fa.

*Pyroxene* (34 per cent) shows somewhat variable optical properties. The positive axial angle is around 58°, and the mean index is about $\beta = 1.700$.

The index indicates an amount of not less than 40 per cent diopside, and the axial angle shows that no clinoenstatite or acmite molecules are present in appreciable amount. The residual 60 per cent must consequently be chiefly hedenbergite. The amount of sesquioxide is presumably small, but can not be accurately stated.

*Ore* (6 per cent) is a mixture of ilmenite and magnetite.

*Feldspars.* Very few phenocrysts (much less than 1 per cent) of labradorite-bytownite (about 72 An) are present.

[13] WASHINGTON, Am. Journ. Sci. 5: 499. 1923.

Some of the well developed thin feldspar laths in the groundmass have a mean index of refraction, $\beta$ = 1.555–1.550; they are optically positive with 2V about 85°, and may consequently be regarded as normal plagioclase with the composition of a calcic andesine. The more sodic feldspars, however, are anomalous,[14] a great many of them show the following properties: $\beta = 1.545 \pm 0.002$, (+) $2V = 84° \pm 4°$.

Some feldspar powder of the rock was obtained by magnetic separation and was embedded in different index liquids. On grains lying normal to an optic axis the following measurements were made:

| $\beta$ = | 1.552 | 1.550 | 1.545 | 1.540 | 1.535 |
|---|---|---|---|---|---|
| Approx. axial angle | (+)85 | (+)85 | (+)84 | (+)75 | (+)50 |

Variations of the axial angle from +10° to +65° were observed on grains of low refringence ($\beta < 1.540$).

That the relation between the refringence and the axial angle in these feldspars is very different from that in the plagioclase series is shown graphically in Fig. 1. Since all the potash feldspars and also the nephelite are optically negative, they can with certainty be excluded, and thus the only possible explanation again seems to be that these feldspar-like minerals belong to the anemousite series.

TABLE 3.—MODE AND NORM OF OLIVINE PACIFICITE FROM KAULA GULCH, MAUNA KEA

| Mode | | Norm | |
|---|---|---|---|
| Anemousite | 34 | Or | 5.6 |
| Plagioclase (43 An) | 7 | Ab | 19.9 |
| | | An | 6.1 |
| Pyroxene | 33 | Ne | 10.8 |
| Olivine (26 Fa) | 18 | Di | 30.9 |
| | | Ol | 17.3 |
| Ore | 7 | Mt | 4.9 |
| | | Il | 4.3 |
| Apatite | 1 | Ap | 1.3 |

The mode and norm of this rock are entered in Table 3. The method of calculation is the same as that which was used for the rock previously described. The figures are in perfect agreement with the microscopic observations.

[14] The colorless substance of the ground mass was doubtfully referred to nephelite by WASHINGTON, who remarks that its amount is much less than that of the nephelite in the norm.

The calculated average composition of the pyroxenes is as follows:

| | |
|---|---|
| Diopside | 61 |
| Hedenbergite | 35 |
| Acmite | 4 |

The calculated average composition of the anemousite is:

| | |
|---|---|
| Orthoclase | 9 |
| Albite | 54 |
| Anorthite | 12 |
| Carnegieite | 24 |

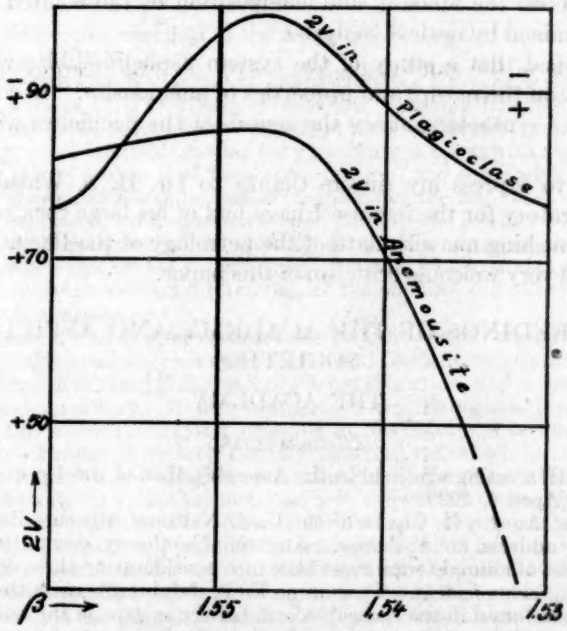


Fig. 1.—The axial angle plotted against the mean index of refraction for the plagioclase series and for the series of feldspar-like minerals occurring in the pacificite. The value at $\beta = 1.559$ is taken from Wright's (Washington and Wright, Am. Journ. Sci. 29: 52–70. 1910) measurements on anemousite from Linosa.

The preceding pages contain all the information on this anemousite feldspar available by analytical and optical methods. Several vain attempts have been made to obtain pure anemousite from the rock for a chemical analysis. But these lavas are too fine grained; very fine

dust and minute grains and skeletons of ore and pyroxene are mixed with the colorless minerals in such an intricate way that even if the rock is ground down so extensively that the powder sticks together like clay, and all methods of mechanical separation are carried out very slowly, it has been impossible to get even approximately pure material. Of course it is possible to concentrate the colorless minerals, but so much of the dark minerals is always admixed that the calculation of the composition of the colorless phases can never be very accurate, because an estimation of the proportion and nature of the colored contaminations in such a finely ground powder would always be a mere guess. If the calculation is based directly on the chemical analysis of the rock, however, both the amount and composition of the colored minerals can be obtained by optical analysis.

It is hoped that a study of the system nephelite-albite will throw more light on the nature and properties of anemousite. In connection with such a synthetical study the genesis of the pacificites will also be discussed.

I wish to express my sincere thanks to Dr. H. S. Washington of this Laboratory for the free use I have had of his large rock collection, for his furnishing me with data of the petrology of the Pacific Islands, and for his very welcome criticism of this paper.

## PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

### THE ACADEMY

#### 225TH MEETING

The 225th meeting was held in the Assembly Hall of the Cosmos Club on Thursday, April 4, 1929.

*Program:* AUSTIN H. CLARK of the U. S. National Museum delivered an illustrated address on *Evolution*. Any tenable theory accounting for the development of animal forms must take into consideration three distinct, but interrelated, sets of facts. These are: *First*, indubitable evolutionary lines, such as those found in the horses; *second*, breaks or gaps in the continuity of these lines, and especially between the lines themselves, as between the cat and the dog lines; *third*, the fact that all fossils, including the very earliest, fall at once into their respective phyla as the phyla are defined on the basis of the data derived from recent animals alone—in other words that in all geological history there has been no change in the interrelationships between the phyla. Perhaps the term *evolution* might be so restricted as to cover only development of animal types within the phyla, the word *mutations* being used to indicate the gaps, and *primagenesis* might be used to cover the original formation of the phyla by different paths of development from the single cell; the entire concept of the development of animal forms might be called *zoögenesis*.

The evolutionary history and present interrelationships of animal types are a reflection of the possibilities for variation afforded in the early stages. These are least in the birds, which form the most unified of any of the vertebrate groups. Indeed, all of the vertebrates together show scarcely more structural diversity than is seen in certain individual species of insects or crustaceans in the course of their life history.

The relationship between man and any one of the apes may be compared to that between the greyhounds and the bull-dogs, which differ physically and mentally both from each other and from the wolf from which they are derived and do not intergrade either with each other or with the wolf. These dogs thus illustrate perfect continuity of descent coupled with abrupt discontinuity of form and mental attributes. The ancestor of man is not known, but probably was not an ape as we understand that term. (*Author's abstract.*)

### 226TH MEETING

The 226th meeting was held in the Assembly Hall of the Cosmos Club on Friday, May 10, 1929.

*Program:* EDWARD W. BERRY of Johns Hopkins University delivered an illustrated address on *The history of the Andes.* Among the major tectonic features of the earth the Andes are unique in their continuous great elevation over 65 degrees of latitude; in that they overhang a coast with several great deeps near shore; and in that they cross much of the equatorial and south temperate zones and hence lie across the paths of the two most continuous and most important wind systems of our planet—the southern trades and the south temperate westerlies. Nearly all of the apparent anomalies of South American climate are explained by this fact, which is also the clue to the most important method for arriving at the amount and date of uplift of the present mountains.

In the central and northern Andes the present coastal region lies in the rain shadow of the moisture-carrying trade winds, gets little moisture from the Pacific because of the cool Humboldt or Peruvian current, and is consequently a desert or semi-desert. In the southern Andes, Patagonia lies in a rain shadow of the moisture-carrying "roaring forties" and is consequently arid. The evidence furnished by late Tertiary fossil plants, which have been collected from a great many localities on both sides of the mountains as well as from great elevations within the montane belt, shows that the major elevation did not take place until near the close of the Tertiary period, or slightly later. Traces of wet lowland tropical forests, whose existing relatives are confined to the basin of the Amazon, are found at elevations of from 11000 to 13500 feet along with petrified woods showing no seasonal rings, and similar floras are found fossil in the Peruvian desert. Similarly, fossil floras indicative of a heavy rainfall, and with coal measures, are found not only along the West Coast in southern Chile, but also east of the present mountains in the, at present, arid belt of Argentina.

These prove that the amount of vertical elevation since Pliocene time amounted to over 5000 feet as a minimum figure. This is corroborated by the present physiography with its discordant stream profiles, by the great topographic maturity of the more elevated as compared with the less elevated parts of the terrain, by the finding of marine Pliocene fossils in the southern Andes at elevations of over a mile, by observed changes in the drainage pattern, and by the distribution of the present life—especially the plants, birds, and freshwater fishes.

The general geologic history of South America was shown to have consisted of sedimentation in a series of geosynclines extending approximately north and south, the western margins of these geosynclines lying progressively farther west during the Paleozoic. The major periods of folding, according to our present information, were in supposed pre-Cambrian rocks, in pre-Carboniferous rocks, in the pre-Mesozoic rocks, and in the pre-Cenozoic rocks. Igneous activity appears to have reached a maximum during the Cenozoic, and the major uplift was many millions of years subsequent to the folding of the rocks. The antecedent times when the Andean segment was above sea level were early Cambrian, and earlier, part of the Ordovician, late Devonian and early Carboniferous, during the Permian (maximum earlier emergence) and most of the Triassic.

The address was illustrated by diagrams and maps showing the main tectonic lines, the climatic elements, etc., and views illustrating the types of country developed in the various climatic zones and in the rocks of various geological ages. (*Author's abstract.*)

### 227TH MEETING

The 227th meeting was held in the Assembly Hall of the Cosmos Club on the evening of Tuesday, November 26, 1929.

*Program:* The meeting was devoted to a symposium on *The 1929 Scientific Explorations in Alaska.* Brief addresses on the various phases of the work were given by ALEŠ HRDLIČKA for Anthropology, H. B. COLLINS for Archeology, R. Y. STUART and E. E. CARTER for Forestry, PHILIP SMITH for Geology, and W. R. GREGG for meteorology. Abstracts of most of these addresses follow:

The 1929 anthropological researches of the speaker in Alaska were devoted to the Yukon River, throughout its extent (2300 miles). Their main objects were to secure anthropometric data on the remaining full-blood Indians and Eskimo along the river; to collect whatever older skeletal remains might still be found along the river; and to advance as far as possible our knowledge of the earlier settlements or migrations along the Yukon River. Substantial and interesting progress was made in all these directions, notwithstanding the inclement season. The expedition resulted in the securing of valuable data as well as much of the older skeletal material, and due to good fortune brought also a large series of specimens belonging to the fossil ivory culture of the northwestern Bering Sea and northeastern Asia. (*Author's abstract.*)

Archeological investigations of the past four years around Bering Strait have revealed the existence of an ancient phase of Eskimo culture more highly developed, especially in regard to art, than any since known to the Arctic regions. This old Bering Sea culture is apparently ancestral to the extinct Thule culture, the most ancient Eskimo culture of the eastern regions. However, there may possibly have been a late return migration which superimposed certain Thule traits on the older Bering Sea culture. A vague similarity in art and other general resemblances in material culture may indicate an ancient connection with the Indians of the Northwest Coast, although this cannot be determined until some knowledge is had of the archeology of the latter region. The rich curvilinear art of the old Bering Sea culture has been traced through a transitional stage, much less elaborate, into the still simpler patterns of the modern Eskimo. The early stages have not been found. Evidence of a direct and indirect nature points to Northeastern Siberia, between the Anadyr and Kolyma Rivers, as the probable place of origin of the old Bering Sea culture. (*Author's abstract.*)

There is great need for continued employment within the Territory. The activities there are largely seasonal. The fishing season is quite short and the timber and mining work must be curtailed in the open during the more rigorous months. The largest opportunity for building up a twelve months pay roll seems to lie in the establishment of forest industries in the Territory, such as the pulp and paper industry, which could operate their plants throughout the entire year. There is also a large opportunity open for the development of trade in fur-bearing animals, if the proper protection is given to the range available to them. The need for protection in this respect is much greater in interior Alaska than in southeastern Alaska because the fire hazard is more acute in the interior. (*Author's abstract.*)

Five projects were undertaken by the Geological Survey, namely, (1) in coöperation with the Forest Service inducing the Navy Department to send a detachment of airplanes to southeastern Alaska to photograph 12,000 square miles for mapping and study and participating in the conduct of the work in the field; (2) a reconnaissance of the Alaska Range at the head of the Copper River valley and extending northward into the Tanana Valley; (3) an exploration of the western slopes of the Alaska Range west of Cook Inlet and north of Lake Clark; (4) a scouting trip into parts of the Yukon-Tanana region of central Alaska, with a view to visiting tracts that had not heretofore been studied and making a comprehensive correlation of the geology of that general region; (5) the installation of a new seismograph at Dutch Harbor, Unalaska Island, and the rehabilitation of the seismograph at Kodiak Island and the placing of observers at each of these stations. In addition, the Geological Survey carried on its usual investigations of the general development of the mineral resources of the Territory and its technical administrative duties relating to the operations under leases and permits granted for mining certain mineral deposits on Government-owned lands. (*Author's abstract.*)

In 1927 the Alaskan Legislature requested coöperation and assistance from the Federal Government in the development of facilities for safe and efficient flying in the Territory. One of the aids specially requested was the organization of an airways weather service. A definite start to this end was made early in 1929. Fairbanks was chosen as the organization center largely because it is the point from and to which there is the greatest amount of flying. Five substations have been established, at Anchorage, Crooked Creek, Dillingham, Golovin and Ketchikan. These regularly report by Signal Corps radio twice daily, or oftener if necessary, to Fairbanks. In addition, reports are received from twelve other stations which had previously been established. The observations are used not only for the information they give as to current conditions but also as the basis for flying-weather forecasts. In addition, permanent records are kept and these will be used in statistical and other studies of conditions in this region,—one of the most interesting, meteorologically speaking, in the world. (*Author's abstract.*)

WALTER D. LAMBERT, *Recording Secretary.*

## SCIENTIFIC NOTES AND NEWS

The Geological Society of America, together with its affiliated organizations, the Mineralogical and Paleontological Societies, held their annual meetings from December 26th to 28th in Washington, celebrating the fiftieth anni-

versary of the creation of the U. S. Geological Survey. Most of the sessions were held at the Wardman Park Hotel, but some at the National Museum. Thursday evening the retiring President of the Geological Society, Professor HEINRICH RIES, gave an address entitled Some Problems in the Non-metallics, pointing out how much remains to be learned as to the origin, significance, etc., of many deposits of non-metallic minerals. In all about 125 papers on a wide variety of subjects were presented.

A series of five illustrated lectures relating to *The evolution and cultural history of mankind* is in progress under the auspices of the Anthropological Society of Washington. They are being given in the auditorium of the U. S. National Museum and are open to the public. Dr. FAY COOPER-COLE spoke on January 7 on *The coming of man*, and Dr. ALEŠ HRDLIČKA on January 21 on *The differentiation of man into races and his spread over the earth.* The remaining lectures are as follows: February 4, Dr. CLARK WISSLER, *The culture area;* February 18, Dr. HERBERT J. SPINDEN, *The Civilizations of Middle America;* March 4, Mr. NEIL M. JUDD, *Prehistoric pueblos and cliff-dwellings of the Southwest.*

Mr. HERBERT J. KRIEGER, of the National Museum, is continuing field work in Santo Domingo, where he has been carrying on anthropological researches during the past two years. Mr. HENRY B. COLLINS is inspecting excavations at village sites at Vaughan, Miss., where work is being carried on by the University of Mississippi.

Mr. GEORGE G. AINSLIE, of the Bureau of Entomology, is spending several months at the National Museum in a study of certain groups of moths.

Mr. KURT TEICHERT, who has a Rockefeller Foundation fellowship in paleontology for 1930, is studying American Ordovician and Silurian fossils in the National Museum for comparison with those of Europe.

Dr. F. DREVERMANN, Director of the Senckenbergische Institution at Frankfort, Germany, recently visited the department of geology of the National Museum to examine methods of preservation and exhibition of collections.

The second half-year of the Bureau of Standards Educational Courses has recently begun. In addition to the continuation of most of those announced in This JOURNAL **19**: 442, there are to be courses in advanced radio theory and the theory of elasticity given during this period.

The second semester of the Department of Agriculture Graduate School has also opened. New courses comprise: Physiology of plant growth and development, Russian for beginners, and business cycles in relation to agriculture.